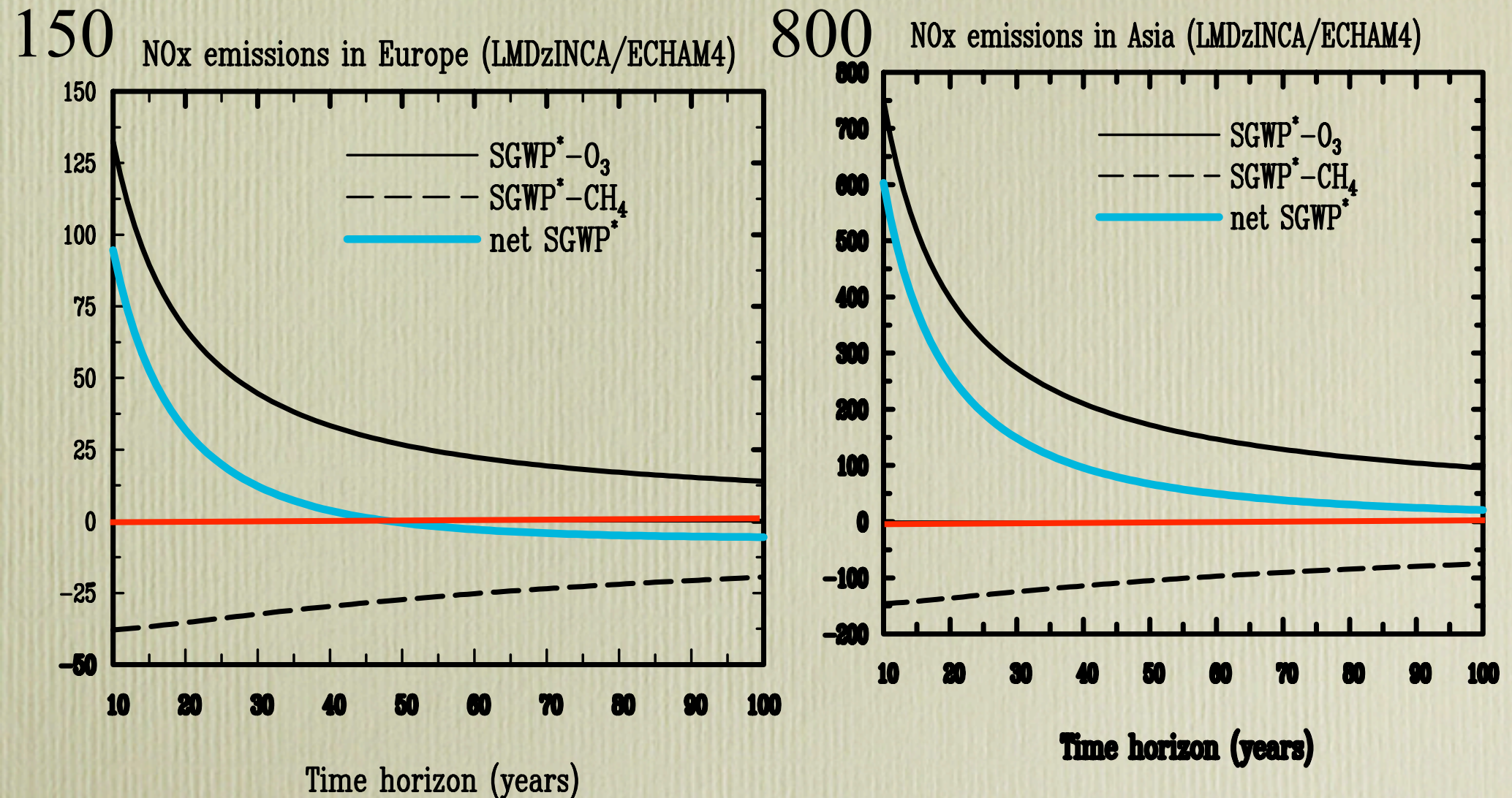


# Nitrogen

- Effects of NO<sub>x</sub> depend on background state, and therefore on location (Asia≠Europe, surface≠aircraft)
- Effects of NO<sub>x</sub> depend on time (sign change possible as diff. between 2 larger numbers)
- NO<sub>x</sub> deposited on ecosystems: increased N fertilization, N<sub>2</sub>O & NH<sub>3</sub> up, CO<sub>2</sub> down, or increased acidification? (marine)
- impact on Methane+Ozone probably negative, overall nitrogen impact unclear



# CH<sub>4</sub> and O<sub>3</sub> response to NO<sub>x</sub>





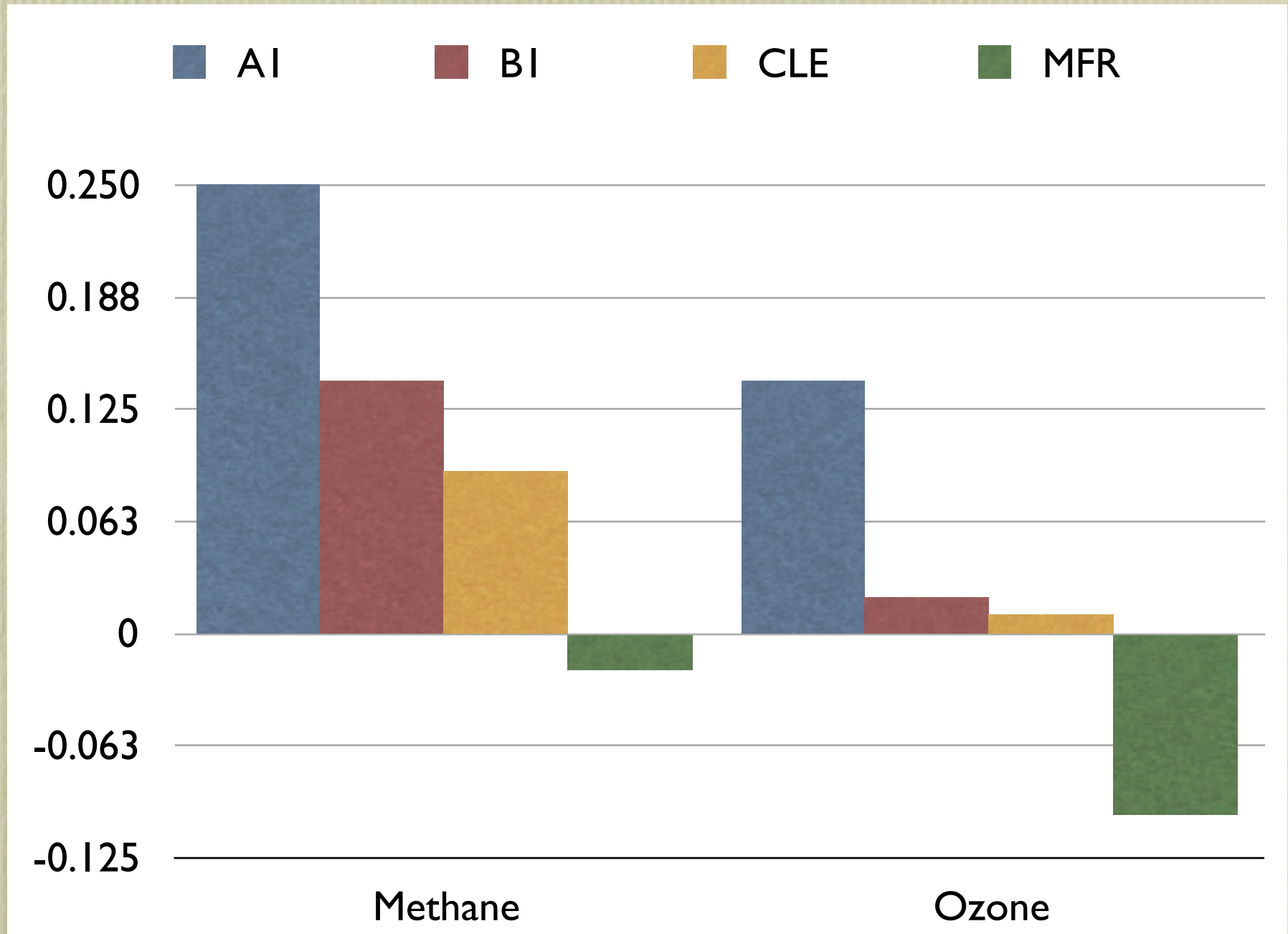
# Methane and CO

- CO and CH<sub>4</sub> lead to additive O<sub>3</sub> and methane responses
- Regional differences small: CO ~20-30%, CH<sub>4</sub> smaller
- CO and CH<sub>4</sub> share of GHG forcing using SGWP (Rypdal et al, 2005)

—	USA	India	China
— 20-yr horizon, CO:	9%	13%,	11%
— CH <sub>4</sub> :	28%	57%	41%
— 100-yr horizon CO:	9%	12%	8%
— CH <sub>4</sub> :	13%	36%	22%

- Methane biggest target (0.8-0.9 W/m<sup>2</sup>)

# 2030 changes





# Actions

- Energy efficiency actions on fossil fuel and transport clearly beneficial (health, \$, climate)
- NO<sub>x</sub> and SO<sub>x</sub> pollution will be reduced for air quality concerns
- makes reduction of methane emissions even more paramount (black carbon/SO<sub>x</sub>)
- $\sim 0.1$  W/m<sup>2</sup> from resulting ozone decrease
- reduction in residential biofuel burning
- Methane reductions:  $\sim 25\%$  anthropogenic cost-effective, leads to about  $-0.1$  W/m<sup>2</sup> (+O<sub>3</sub>)
- Reevaluate every decade!

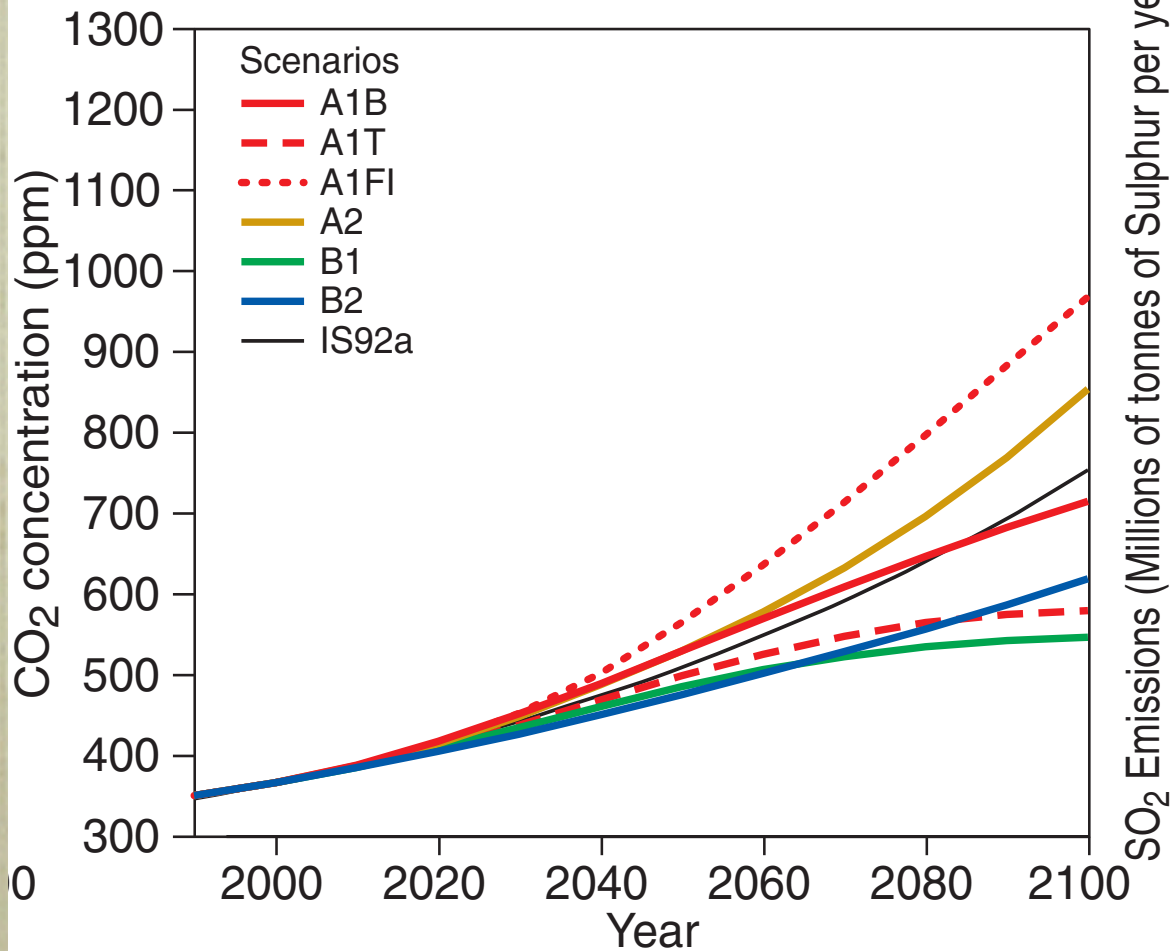
Jim Hansen says

Take a bite out of  
global warming, eat a  
turkey burger!



# Optimism?

**(b) CO<sub>2</sub> concentrations**



- $\sim 0.1-0.2 \text{ W/m}^2$  reduction in forcing over next few decades



# Feasible methane reductions?

- Current emissions  $\sim 550$  Tg/yr
- Fossil fuel & waste/landfills (Methane to Markets):  
30-40 Tg/yr landfills,  $\sim 60$ -70 Tg/yr mining, venting,  
pipelines,  $\sim 15$ -20 Tg/yr coal burning
- Rice cultivation:  $\sim 25$ -40 Tg/yr
- Ruminants:  $\sim 70$ -90 Tg/yr
- Biomass burning (e.g. Streets proj.):  $\sim 20$ -40 Tg/yr
- Climate: wetland emissions may grow, oxidation  
capacity may increase
- $\sim 75$ -80 Tg/yr to get  $0.10$  W/m<sup>2</sup> reduction

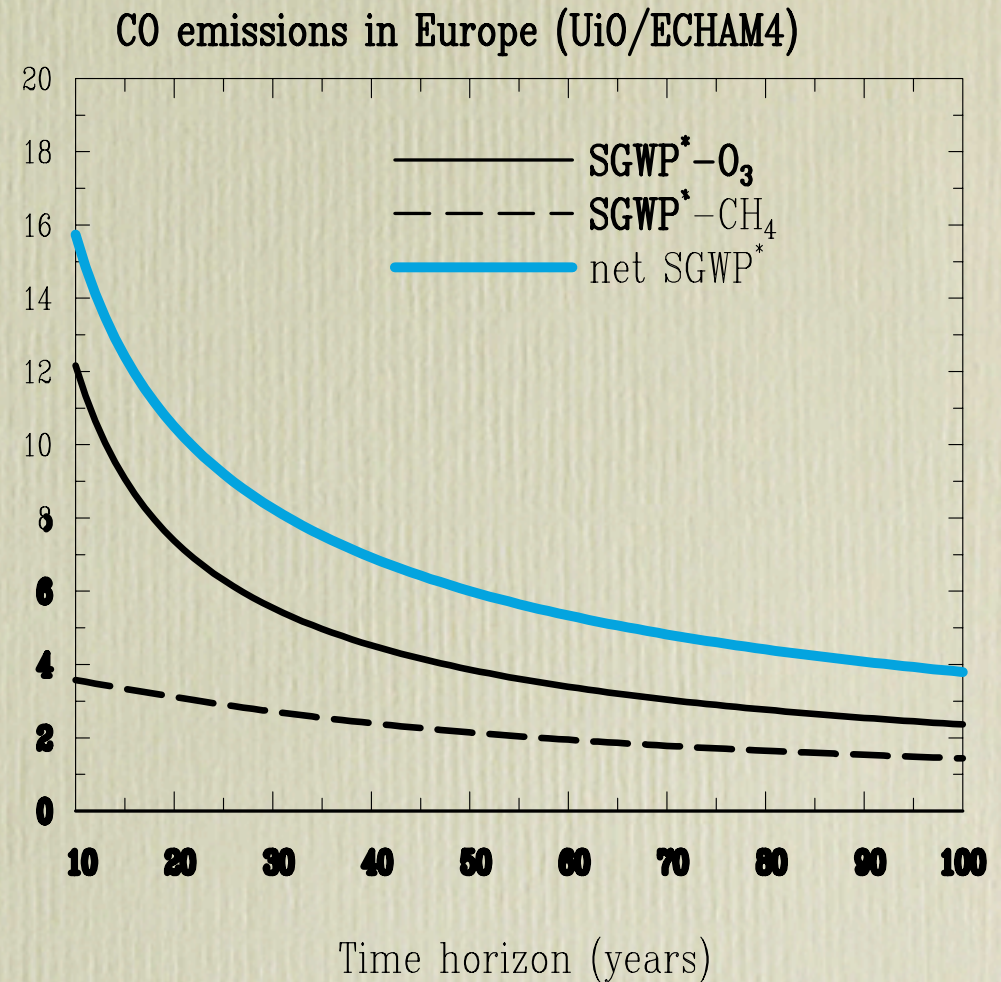
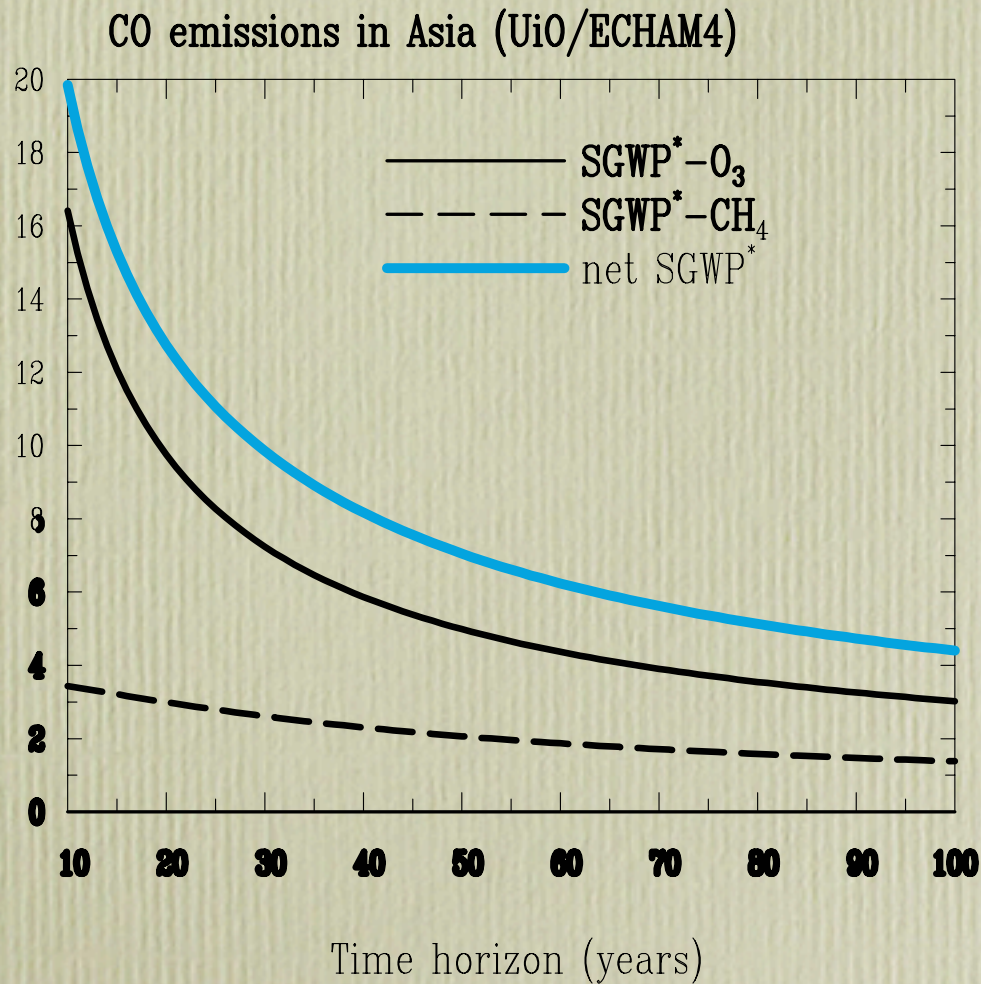


# Non-CO<sub>2</sub> Greenhouse Gases

- Short-lived, so impact of reductions can be strongly dependent upon location and time horizon



# CH<sub>4</sub> and O<sub>3</sub> response to CO





# Linearity of response to CH<sub>4</sub> changes

